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THE FIRST ERTS-PICTURES OVER SKÅNE

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THE FIRST ERTS-PICTURES OVER SKÅNE

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ERTS-1

A new satellite program was introduced when ERTS-A was sent /19 *
up from Vandenberg Air Force Base 23 July 1972. When the satellite had got into orbit and certain technical equipment had been found to operate satisfactorily, its operational mission was started. The satellite was then designated ERTS-1.

The American ERTS program (Earth Resources Technology Satellite), which starts out by sending up two unmanned satellites with an interval of one year, intends to use remote sensor technology (see Geogr. Not., 1968:3) to try to develop methods for collecting data for evaluating and managing the earth's resources. With the wide meaning the resource concept now has there are a large number of both practical as well as purely scientific fields of activity which are affected by the defined mission. Scientists from all countries have been invited to participate in the processing and application of recorded data on a national basis as well as cooperating in developing methods within the framework of the program. More than 300 projects from 37 countries are included in the experiment. Two institutions in our country are active in the ERTS program, namely the Norrland Foundation in Luleå and the Geographical Institution in Lund.

ERTS-1 returns every 18'th day

ERTS-1, which as far as the satellite configuration itself is concerned is a modified Nimbus vehicle (fig. 1), was launched into a circular and almost polar orbit with a period of 103 minutes

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*Numbers in the margin indicate pagination in the foreign text.

and moving from north to south on the day side of the earth. The altitude of the orbit is a little more than 900 km (will vary between 900 and 950 km), and from this altitude the satellite's sensor system covers a 185 km (100 nautical miles) wide zone of the earth's surface. ERTS-1 is also synchronized with the sun. It passes our latitudes at about 10:30 hours.

Through the rotation of the earth a new zone of the earth's surface will be covered during each rotation. Each equator passage lies 25.8° west of the previous one. The closest adjacent area (to the west) will not be photographed until the next day, during which time the satellite has completed fourteen rotations.

At the equator there is an overlap of 14% in longitude between the 185 km wide recording passages. This overlap then increases towards the poles (fig. 2) and becomes 57% at 60° latitude. Complete coverage of the earth's surface requires 251 rotations or 18 days, which thus is the length of an observation cycle.

However, because of the overlap, recording may take place /20
at somewhat shorter intervals, especially at higher latitudes. The opportunities for recording obviously also depend upon the possibilities for looking down at the earth, i.e., it depends upon the cloud cover. Data has been requested for each project on what cloud cover (in percent) can be tolerated over the test area while still obtaining the information intended. If the weather forecast shows higher cloud cover, no recording is done.

The satellite sensors are not in continuous activity at other times either during the trip over the earth's day side. Only when the satellite passes over areas which are included in the program (for the Lunda project southern Sweden south of 59°N) are the sensors activated. The reason for this is the available capacity for storing observational data in the satellite (tape recorders) as well as problems with the energy supply (solar cells) for the satellite instruments.

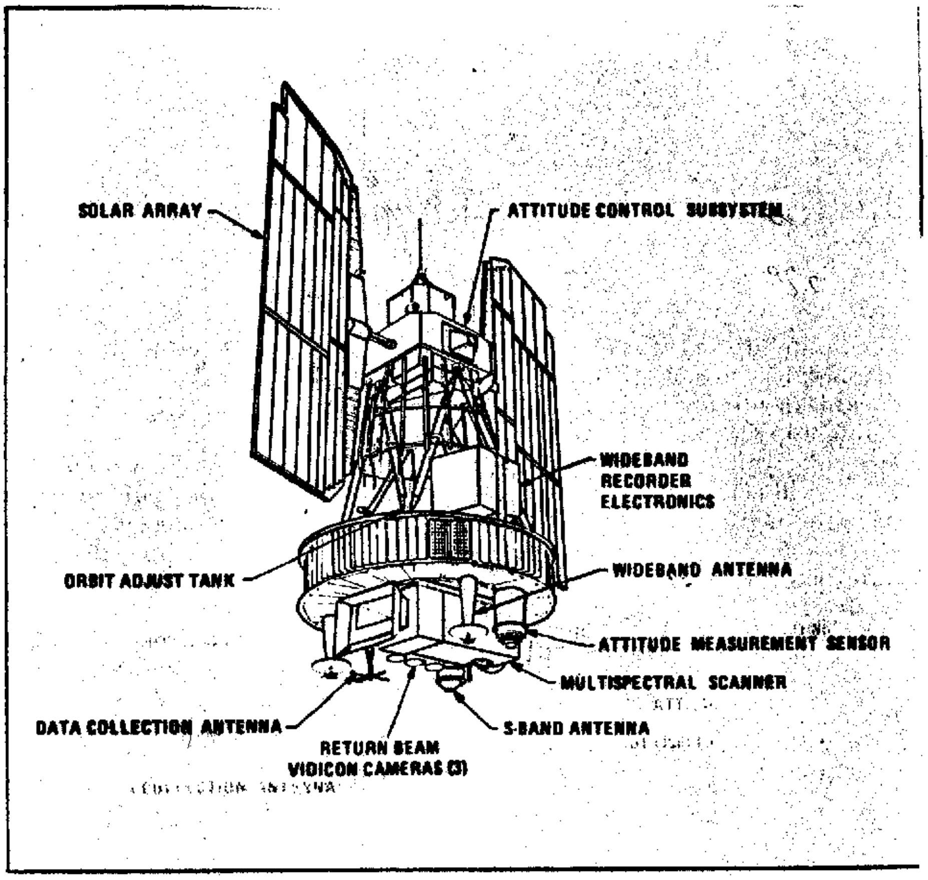

Fig. 1. ERTS-1 (from "Data Users Handbook").

Information from the earth's surface is recorded with three data collection systems. /21

ERTS-1 is equipped with a television camera system, RBV (Return Beam Vidicon), a multi-spectral scanner (MSS) and a data collection system (DCS). This latter is intended for collecting data from special instrument platforms on the surface of the earth with special instrument equipment according to the alignment of the project (e.g., recording of temperature, snow depth, soil moisture, runoff conditions). Data are released from

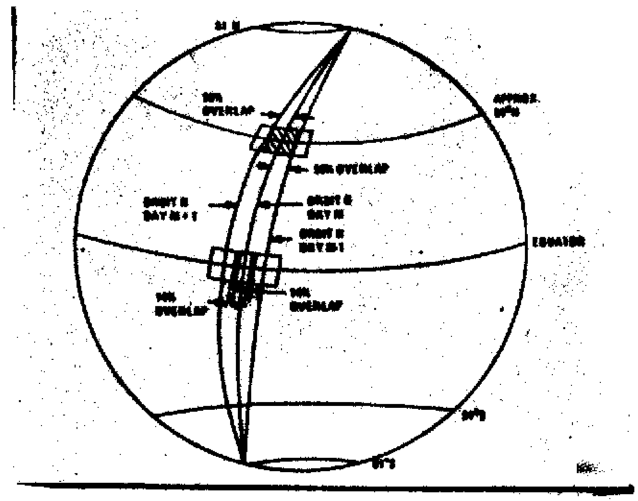

Fig. 2. Lateral overlap between adjacent paths (from "Data Users Handbook").

these platforms when the satellite passes.

The RBV sensor consists of three cameras (fig. 3) with simultaneous exposure but with recording in different wavelength ranges, 0.475-0.575 µm, 0.580-0.680 µm and 0.698-0.830 µm. The two first mentioned intervals belong to the visible part of the electromagnetic spectrum, while the third extends into the IR range.

The MSS sensor consists of a line scanner (fig. 4), which records within four spectral ranges, 0.5-0.6 µm, 0.6-0.7 µm, 0.7-0.8 µm and 0.8-1.1 µm. The two last ones thus belong to the short wave IR range, "near infrared". (Concerning multi-spectral recording with line scanner see Geogr. Not., 1970:4).

The data (video signals), which are recorded by the RBV and MSS systems, are transmitted from the satellite by radio to one of the three main stations in the USA (there is also a special station in Canada). When the satellite is moving in paths distant from these stations, the information is not sent directly (real time) but is stored in tape recorders in the satellite for later transmission to a ground station.

From the ground station the received information such as video data goes on magnetic tapes to a data processing center where the pictures are produced. Geometrical corrections can thus be introduced so that a higher degree of cartographic accuracy can be obtained in the pictures. RBV and MSS data /23 can be delivered, not only in the form of pictures, but also on magnetic tape for automatic processing in computers.

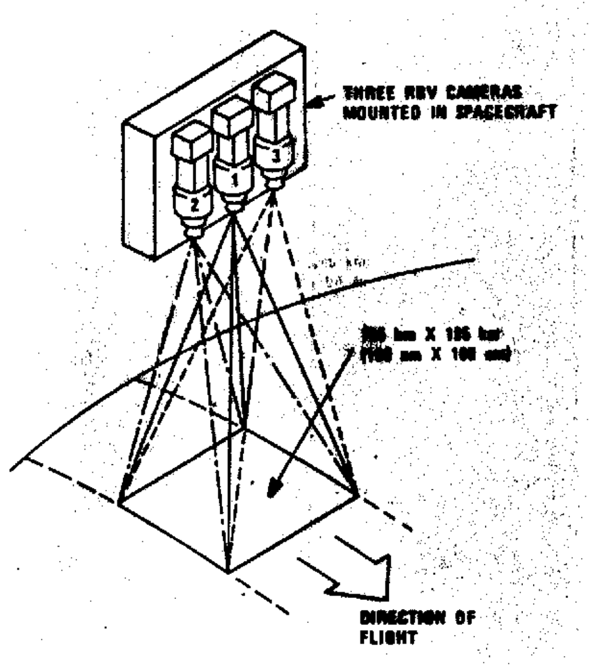

Fig. 3. The RBV sensor in ERTS-1 (from "Data Users Handbook").

The geometric accuracy is suprisingly high. According to data in investigations carried out on early ERTS material, MSS pictures showed an RMS (root mean square) error of 378 m. This is for the ordinary picture material (bulk photographic product). On so-called precision photographic products, where mathematical corrections of known systematic error (radiometric and geometric) have been introduced in the generation of the pictures, the RMS error has been calculated at 164 m. For the RBV sensor the

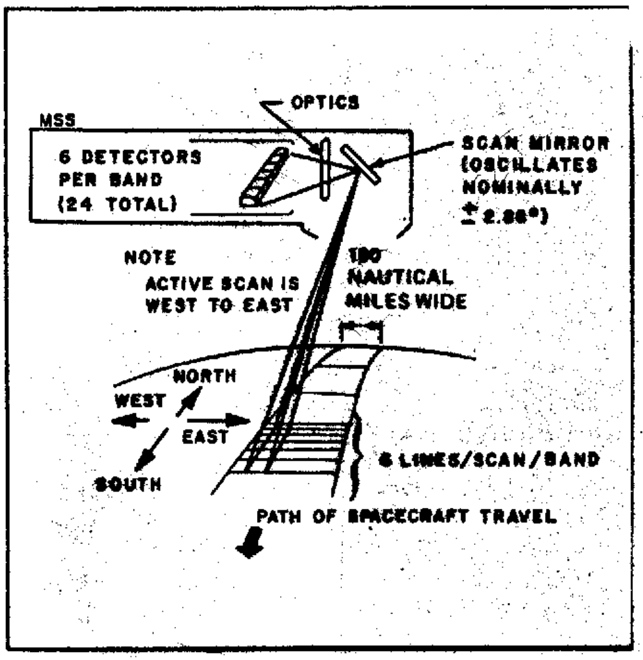

Fig. 4. Basic diagram of the MSS sensor in ERTS-1 (from "Data Users Handbook").

accuracy is higher. Its video material is therefore most suitable for purely cartographic purposes.

3 August 1972 operational problems occurred in one of the two tape recorders in the satellite, and it had to be shut off. This meant that the remaining tape recorder did not have the capacity for storing both RBV and MSS data. In choosing between RBV and MSS recording one decided on the latter primarily because MSS gave data further out in the IR band. The RBV sensor is now shut off, but it can be activated again and used when ERTS-1 is within range for direct reception (without taping) from a ground station. This is basically over North American areas.

Skåne was mostly hidden by clouds on the first ERTS pictures

During the first ERTS passages over southern Sweden there was no recording of pictures because of clouds. During the late summer and fall the passages have also happened to coincide with cases of relatively poor visibility over southern Sweden. Skåne has not yet (Dec. 1972) been pictured in a completely cloudfree situation, but on a number of pictures the ground surface appears extremely clear (see fig. 5 and 6) in spite of the enormous recording range, more than 900 km. The large distance is easier to visualize if it is compared with a distance on ground, e.g., Lund-Umeå.

The picture examples, fig. 5 and 6, are from 7 October 1972 and show only parts of Skåne without clouds, but can still give some information both as concerns the reproduction of the ground surface as well as purely technical information on the pictures.

As far as the appearance of the pictures is concerned it should be emphasized that both pictures refer to one and the same case of recording. The difference between them is due to the fact that they were recorded (by the MSS sensor) within different wavelength intervals in the electromagnetic spectrum. Figure 5 is a picture in the spectral interval 0.5-0.6 μm, i.e., in the middle of the visible spectrum (yellow-green), while fig. 6 is from the MSS channel 0.8-1.1 μm; thus in the latter case outside the visible spectrum.

It is clear from the pictures how haze and light veils of clouds constitute a greater hindrance for recording pictures of ground information within the visible spectral range than within the IR interval (here represented by the wavelengths 0.8-1.1 μm). - The light cloud strips, which occur over water, are condensation strips from aircraft. That they appear dark against an underlying cloud cover is probably due to a shadow effect.

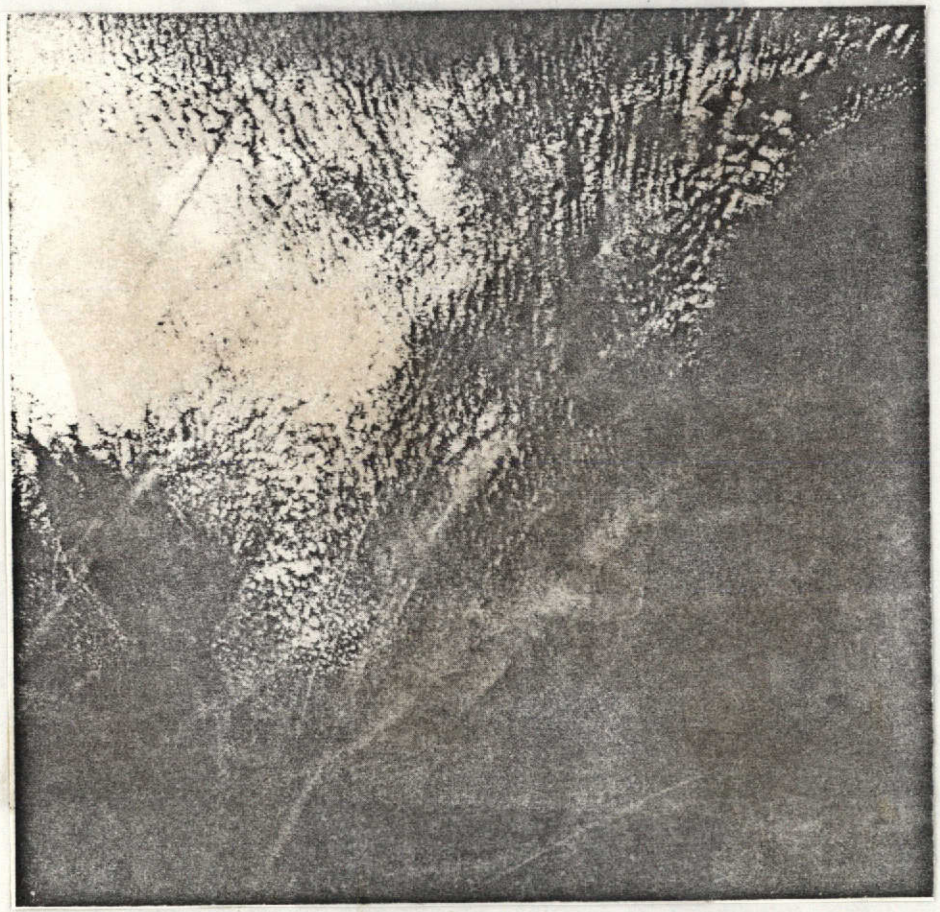

Figure 5. Part of ERTS picture (channel 4, MSS 0.5-0.6 μm) over Skåne as well as part of Själland and Bornholm 7 October 1972, 10.41 a.m. Approximate scale 1:1.5 million. Photo NASA.

The pictures, fig. 5 and 6, are reproduced for reproduction by enlarging 70 mm film negatives (approximately 3 X). The negatives make possible an even greater enlargement. The resolution is better than expected. Objects of a size of 100 m can often be distinguished. Objects considerably smaller than 100 m with a favorable background or object shape can sometimes also appear. However, in this connection the intention was not to achieve a detailed analysis but only a clear presentation of the variations in the pictures.

Ground contours appear most clearly in the IR version (fig. 6), but the accentuation of some of the beach elements is lost here. Sand beaches and shallow coast areas beyond, e.g., the Falsterbo peninsula, Sandhammaren and the Hanö bay, are accentuated clearly in fig. 5. The land boundaries in the area near land at Sandhammaren are clear in both versions of the picture. /25
However, this is a consequence of the utilization of the land.

In Öresund Ven and Saltholm, which right now are of interest in the question about the airport and the bridge, are shown clearly (fig. 6). Malmö is mostly covered by a cloud, while parts of Copenhagen appear. Parts of the harbor areas as well as Kastrup airport on Amager could be seen on the original pictures.

The strong dark shading of water surfaces in IR pictures involves a strong accentuation of sea surfaces in fig. 6. On the other hand, the Vomb lake and the larger lakes upland in Skåne appear only faintly in figure 5. Some of the lakes in north-east Skåne can be seen because of a strong contrast effect against the cloud veils in fig. 6. They can not be identified in fig. 5.

The spectral range 0.5-0.6 μm (fig. 5) is superior to the IR range for showing certain forest areas. This can be seen by comparing both versions of the pictures for Bornholm. Thus the /26
forest areas at Almindingen and north of it are clearly accentuated in fig. 5 but are not shown in fig. 6.

Original terrestrial maps

For analysis of large areas (regional analysis, Landschaftsgliederung) the geographer has to resort to maps, and at present there are good maps available. But maps must necessarily be generalizations with everything that that involves.

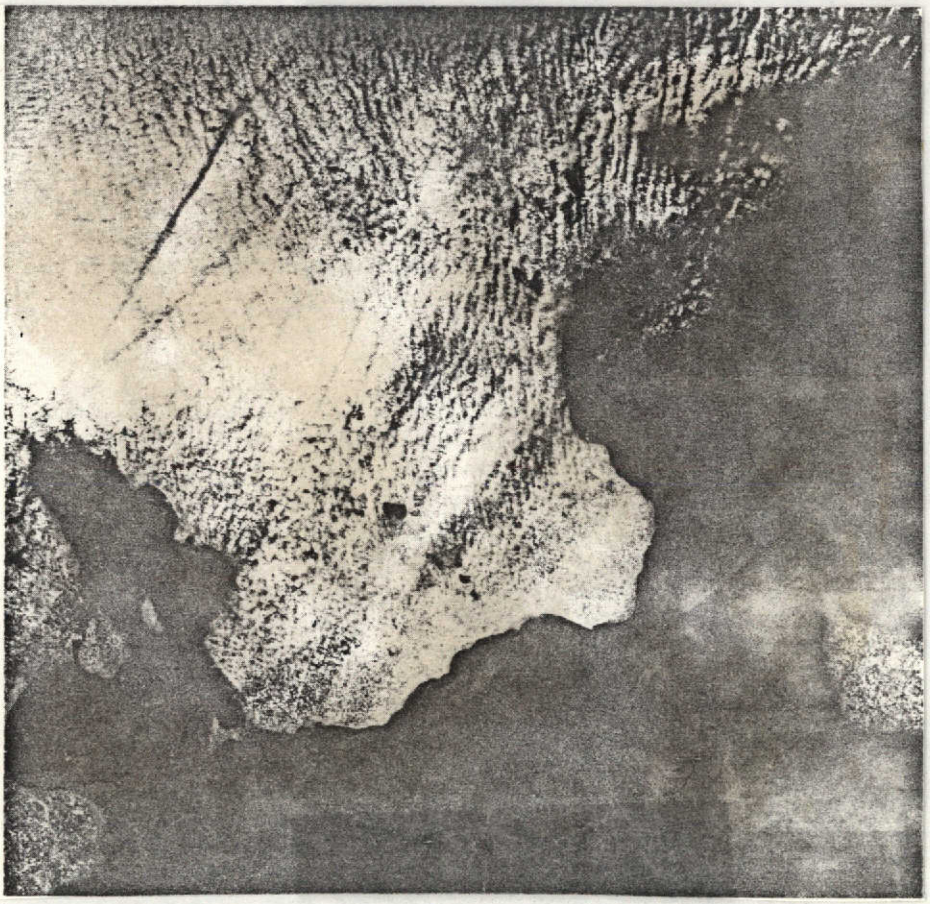

Fig. 6. Part of ERTS picture (channels 7, MSS 0.8-1.1 µm) over Skåne as well as parts of Själland and Bornholm 7 October 1972, 10.41 a.m. Approximate scale 1:1.5 million. Photo NASA.

After having seen and worked with some of the first ERTS pictures it seems clear to me that the geographer in this picture material now has got unique possibilities for studying original terrestrial maps as presented by the surface itself as it changes with season and weather. This can for the first time be done in a base scale which with or without magnification make the representations really interesting from a regional geographical point of view and with a resolution and map accuracy which places the ERTS pictures in a special class compared with pictures from the other unmanned satellites (see Geogr. Not., 1972:4).

The static picture of the earth's surface, which a conventional map easily emphasizes for the benefit of learning important geographical local names in school (mountains, rivers, plains, cities, etc) but maybe with a certain detriment to the understanding of the dynamic landscape and man's living surroundings, can be complemented by the ERTS pictures. This complementation can be more important the more man affects his environment, i.e., the dynamic landscape, and this effect calls for global control.

Since this publication addresses geography teachers, I cannot avoid putting forth a final reflection which has become gradually more important the more I have worked with aerial photographs and satellite picture material. - Isn't it strange that at the same time as geography is taken off Swedish school children's timetables, in the rest of the world one is striving more and more to look at the earth from a geographical point of view with the complete aids of modern technology?

Abstract

Scientists from many countries are cooperating in the American ERTS program, which uses unmanned satellites to collect data for evaluating and managing the earth's resources. ERTS-1 has equipment for collecting data at several different wavelength ranges, for storing the data, and for transmitting it to ground. Accuracy and resolution are found to be exceptionally good and present unique possibilities for studying the earth's surface under differing weather conditions and seasons.